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THE PROBLEM OF ACUTE INFECTIOUS JAUNDICE IN THE UNITED STATES.

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Acute infectious jaundice is an acute infectious disease characterized by malaise, prostration, and gastrointestinal symptoms at onset, by fever of varying degree and by jaundice of varying intensity and duration. In severe cases bleeding from mucous surfaces and albuminuria are common. In moderately severe cases the rather high fever, marked prostration, and absence of local signs tend to exclude local disease of the biliary tract and present the clinical picture of an acute infection. Light cases of this affection, however, seem to be clinically indistinguishable from ordinary catarrhal jaundice and therefore are seldom diagnosed correctly in the absence of an outbreak of the disease, which naturally directs attention to the probably infectious character of the malady.

In presenting this brief paper the writer desires to:

1. Emphasize the aspects of the disease which are of special interest to sanitarians in the United States.
2. Briefly outline the epidemiological problems of the disease.
3. Indicate the procedures for their study by laboratory methods.

Prevalence of the Disease Among Troops in Europe.

It is well known that outbreaks of jaundice have occurred at different times among the French, British, Italian, German, and Russian troops. The geographical range of prevalence has been from Belgium to Gallipoli. In most of the outbreaks the mortality has been low, but in some of the commands the attack rate has been high. At this time the weight of evidence indicates that the disease in the great majority of instances, if not in all, has been due to the "*Spirochæta icterohæmorrhagiæ*" of Inada (1916) and his coworkers. This organism was first demonstrated as the cause of a severe form of the disease prevalent in Japan.

Prevalence of the Spirochæta Icterohæmorrhagiæ Among Wild Rats in the United States.

Noguchi (1917) found that rats captured about New York City were infested with a spirochæta identical in appearance with that causing acute spirochætal jaundice in man. This worker, by means of cross immunity tests, presented further evidence that the parasites causing the human disease in Europe and Japan and those found in New York rats were the same. Jobling (1917) found that of more than a hundred rats captured in Nashville, Tenn., at least ten per cent carried similar spirochætes in their kidneys. The writer has found a similar prevalence of the *Spirochæta icterohæmorrhagiæ* in wild rats captured in Washington, D. C. As far as can be made out the organisms found by different workers in the United States correspond very closely in appearance and pathogenicity for guinea pigs with those infecting human beings in the trenches in Europe and in the mines of Japan. The evidence then seems to indicate pretty conclusively that the *Spirochæta icterohæmorrhagiæ,* the cause of acute spirochætal jaundice in man, is rather widely disseminated among wild rats living under such different conditions of environment as obtain in New York, Washington, and Nashville. Reports of the degree of prevalence of these parasites in the rats throughout the country are awaited with considerable interest.

Reported Occurrence of Epidemic Jaundice in the United States.

A search of the literature reveals a number of outbreaks of jaundice occurring from time to time in this country. Even though few and far between, on account of the prevalence of the causative agent in wild rats and the fact that outbreaks of jaundice tend to occur among troops, these reports deserve at least a passing consideration.

An account of an outbreak of jaundice among troops in the War of 1812 has come down to us. Acute infectious jaundice has been stated to have been highly prevalent during the Civil War and various numerical estimates of its prevalence appear in the literature. The following quotation is taken from the Medical and Surgical History of the War of the Rebellion prepared under direction of the Surgeon General, United States Army: "Jaundice occurred frequently in the progress of the malarial or other fevers as the result of morbid changes affecting the liver or blood. The yellow coloration in these cases was mostly an incident or symptom of the well-defined primary disease. There were, however, a large number of hepatic or hæmatic disorders in which the alteration of color represented so prominent a symptom that the disease was recorded under the heading of jaundice. Not less than 71,691 cases of this kind were reported among white troops (Union Army). Generally the cases were sporadic, but sometimes a series occurred in a command constituting a local epidemic."

While in the report just quoted the association of jaundice with disease of the liver and malaria is recognized, the records contain several accounts of clear-cut outbreaks of jaundice and fever corresponding pretty closely to the descriptions of the trench jaundice observed in the present war. It seems, then, that while outbreaks of acute infectious jaundice, very likely due to spirochætes, occurred during the Civil War, a numerical estimate of the prevalence of the disease should not be attempted.

A search of the literature reveals a number of reports of outbreaks of jaundice among the civil population in the United States. In the majority of these reports no special prevalence of other febrile diseases is mentioned in connection with the cases reported. In many of the cases the observers were impressed with the fact that they were dealing with a condition they had never seen before, basing their diagnosis on the description of the disease as it occurs in Europe.

In all the American reports most of the patients experienced nausea or vomiting, some abdominal distress or pain, headache, and fever of varying degree, followed in a few days by jaundice of varying intensity. In fact from many of the descriptions there is little to suggest a specific infectious disease, aside from the fact that a number of cases as described above would appear at about the same time in a community which was both previously and subsequently free from the disease. Several reports indicate a high mortality among pregnant women. In some outbreaks children seem to have been chiefly attacked, in others adults, and in still others adults and children were equally affected. In some outbreaks males were principally affected, while in others both sexes were affected about equally. In several outbreaks the symptomatology in the fatal cases was strikingly similar, suggestive of rapid necrosis of the liver cells as occurs in acute yellow atrophy of the liver. There is no information as to the occupation of those ill with the disease, nor is it possible to gain any comprehensive idea of the sanitary situation as regards water and food supply, sewage disposal, and the like, under which the disease has occurred in the United States. No adequate study of the pathology of the disease in man in this country has come to the writer's attention. Barker and Sladen found that the blood serum of their cases agglutinated a strain of *B. paratyphosus*.

There is some evidence to suggest that direct contact may have occasionally played a part in transmitting the disease, as in Hanover, N. H. (Gile, 1908), where a number of college students were engaged in surveying roads in the vicinity, camping out at night. From time to time one would become ill with jaundice and fever and return to college. Then cases began to appear in the college itself where the disease had formerly been unknown. Again at Ann Arbor, Mich.

(Cummings, 1915), 12 of the 19 cases had been in contact with a sick college mate previous to contracting the disease. In this outbreak the food supply was apparently not a factor, as nearly all those attacked ate at separate boarding houses.

Outbreaks of Infectious Jaundice in the United States (Civil Population).

Place.	Approximate population.	Year.	Months.	Cases.	Deaths.	Reported by—
Rocky Mount, N. C.	?	1849-50	Nov., Dec., Jan.	About 40	Not stated.	Pittman, N. Orleans Med. J., v. 6, p. 694.
Halifax Court House, Va.	?	1857-58	Fall and winter.	Not stated.	Apparently none.	Faulkner, Md. & Va. Med. J., v. 15, p. 355.
Savannah, Ga	30,000	1880	Jan., Feb	80	None	Nunn, Atlanta Med. & Surg. J., v. 28, p. 6.
Birmingham, Ala.	3,000	1881-82	Sept.-Jan	"Many"	"Few"	Sears, Trans. Med. Assoc. State of Alabama.
Plainfield, Mich	100	1886-87	Dec., Jan	22	None	Green, Phys. & Surg., v. 9, p. 199.
Geneva, N. Y	7,000	1888	Spring	200	None mentioned.	Sweet, Med. Regist., v. 3, p. 317.
Troy, Me	?	1887	do	Not stated.	do	Dodge, Rept. State Bd. Health, Maine, v. 4, p. 266.
Sparta, Wis	3,000	1898	Aug., Sept., Oct.	"Few"	"Few"	Beebe, Trans. Med. Soc., Wis., v. 32, p. 183.
Calumet, Mich., and vicinity.	30,000	1897-98	June-Jan	675	None	Pomeroy, Trans. Mich. State Med. Soc., v. 22, p. 387.
Hanover, N. H	4,000	1899	Not stated	About 25	do	Gile, Trans. N. Hampshire Med. Soc., 1908, p. 181.
Stirling, Kans	2,200	1905	Sept., Oct., Nov.	30	2	Ross, J. Kansas Med. Soc., 1906, p. 407.
Montevallo, Ala		1906	Nov., Dec	Not stated.	None	Wilkinson, Ala. Med. J., v. 19, No. 6.
Talladega, Ala	5,500	1907	Summer and fall.	About 200	2	Dixon, Ala. Med. J., v. 20, p. 320.
Baltimore, Md	558,500	1908	Nov., Dec	6 cases, of 700 inmates of jail.	None	Barker & Sladen, Bull. Johns Hopkins Hosp., v. 20, p. 310.
Andover, Me	750	1908-09	Oct.-Feb	135	do	Leslie, Bost. Med. & Surg. J., v. 161, p. 622.
Austin, Minn	6,960	1910	Sept.-Dec	About 200	do	Collins, J. Minnesota State Med. Asso., v. 31, p. 305.
New York City	4,800,000	1912-13	Oct.-Jan	25 studied at author's clinic.	1	Herrman, Trans. Amer. Ped. Soc., v. 25, p. 85.
Hetland, S. Dak	223	1913	June.-Sept	Not stated.	Not stated.	Grove, St. Paul Med. J., v. 16, p. 109.
Ann Arbor, Mich.	15,000	1915	Spring	25	None	Cummings, J. Mich. State Med. Soc., v. 14, p. 293.

From the table it is evident that, while in certain of the outbreaks a fairly large proportion of the community has been attacked, the case-fatality rate has always been low. As regards seasonal prevalence, it would seem that the fewest cases occurred in the warmer months of the year. Detailed analysis of the reports shows very few cases occurring in the summer as compared with the fall and winter. This is in accordance with a part of the observation of Japanese and European workers, that the disease does not occur in the hottest or coldest weather.

Before closing the discussion as to the prevalence of epidemics of jaundice in the United States it seems fair, in the absence of more definite knowledge, to ask whether such a disease as a separate entity has existed or whether all the outbreaks were not manifestations of some other disease such as typhoid fever or malaria. With regard to malaria it may be said that, while estivo-autumnal malaria undoubtedly caused outbreaks of jaundice in the Civil War, it is contrary to our present knowledge of the distribution of this disease to ascribe such outbreaks as occurred in Maine, New Hampshire, Minnesota, and Wisconsin to this cause. To infer that these cases were due to some vagary of *B. typhosus* would contradict a great mass of clinical experience, which shows that jaundice is a very rare symptom of typhoid fever. The same may be said with regard to paratyphoid infection. In general the seasonal prevalence of acute infectious jaundice seems to be at its lowest just when so-called filth-borne diseases are most prevalent.

Whatever may be the weight attached to such facts as have been stated above they indicate that epidemics of jaundice closely simulating those now known to be caused by the *Spirochæta icterohæmorrhagiæ* have occasionally appeared in this country, and that they were possibly due to this parasite. This latter statement is strengethened by the finding by A. M. Stimson (personal communication) of spirochætes in sections of the kidney of a man who died in New Orleans of a disease characterized by jaundice and fever. These sections prepared by Levaditi's method show spirochætes morphologically similar to the causative agent of acute spirochætal jaundice.

The Problem of the Rat as a Carrier of the Spirochæta Icterohæmorrhagiæ.

The following quotation from Noguchi is well adapted as a starting point in this discussion: "The finding of the causative organism of infectious jaundice among wild rats in America and the identification of this strain with those found in Asia and Europe seem to be particularly important in revealing a latent danger to which we have been constantly exposed but from which we escape as long as sanitary conditions are not disturbed by untoward events."

Long before the present war acute infectious jaundice was recognized to occur especially among troops, among sewer workers, agricultural laborers working in wet soil, and in mine workers. People who handle food as butlers and cooks, in Japan at least, are also said to be attacked with especial frequency. With the universal adoption of trench warfare in the present conflict acute infectious jaundice took a more or less prominent place in the category of trench diseases. Stokes (1917) observed a definite increase in the number of cases among troops during wet spells of weather, followed by a diminution in cases when the weather became dry. It was also noted that a regiment which had a number of cases in the line—i. e., wet trenches—was not infected while in rest billets, but again produced cases when it returned to the trenches. In Japan, Inada

(1916) and his coworkers found that cases of acute infectious jaundice occurred in the wet shafts of the mine, but not in the dry shafts nor on the surface. Some evidence has been presented to show that the hot and cold months of the year are unfavorable to the spread of the disease. Several laboratory workers have been directly infected by the blood of guinea pigs suffering from the disease, at least once with fatal outcome.

The credit of first finding the *Spirochæta icterohæmorrhagiæ* in rodents belongs to the Japanese investigators, who first demonstrated these parasites in the kidneys of field mice. Further investigations in the coal-mining regions of Japan showed that 40 per cent of the wild rats harbored organisms resembling these parasites. Many cases of infectious jaundice in human beings, due to spirochætes, occur in this region. With regard to the spirochætes found in the rats, it was observed that they live in the kidney without injury to the animal, and are excreted in the urine. By means of tests with immune sera, evidence was obtained which indicated that the spirochætes which came from the rats were quite similar to, if not identical with, those derived from human sources. The various strains of these spirochætes all produced the same striking pathological picture in experimentally infected guinea pigs. Guinea pigs were infected by allowing rats to bite them, and it was demonstrated also that the organisms would pass through the unbroken skin of these animals.

English and French workers soon demonstrated the presence of the *Spirochæta icterohæmorrhagiæ* in rats taken from the trenches in which the disease had appeared among troops. Thus Stokes (1917) found 6 out of 15 rats to be infected. On the other hand, Courmont and Durand (1917) examined 50 rats taken in a region where acute infectious jaundice was unknown. The rats appeared perfectly healthy, but four of them were proved by guinea-pig inoculation to harbor the *Spirochæta icterohæmorrhagiæ.* These figures approximate the rate of incidence later obtained for wild rats in the United States. Rat infestation has been demonstrated in other portions of France.

With regard to the relation between rat infestation and human infection with *Spirochæta icterohæmorrhagiæ,* two possibilities present themselves. First, it is possible that no transfer from rats to man takes place, or only exceptionally as in case of a bite. It may be that some cause is at work in the trenches and mines which tends to infect man and rats with the *Spirochæta icterohæmorrhagiæ* entirely independently of each other. On the other hand, it seems more probable that the spirochætes may be interchanged indiscriminately among men and rats living in such environments as obtain in the trenches, by means of their urine. There is evidence to show that infection can take place either through the skin or by the mouth.

There is no adequate evidence that any insect plays a part in the transmission of the disease in nature, although the experimental evidence in this regard is by no means complete. The epidemiology of the disease seems to point rather definitely to a moist soil, at an equable temperature, as a means of keeping alive the virus.

While the problem of the rat in relation to acute infectious jaundice has not been completely worked out, the following statement of the mode of transfer forms a reasonable hypothesis. About 10 per cent of all wild rats wherever located probably carry the *Spirochæta icterohæmorrhagiæ* in their kidneys and excrete them in their urine. If this organism finds a favorable environment in the soil, a sufficient number may live long enough to infect a human being who gets them in the mouth or on the skin. Under these conditions a larger number of rats also take up the spirochætes.

Much more work needs to be done to place the whole matter on a sound scientific basis and to do this it is essential to (1) recognize cases of the disease in man, (2) determine the general prevalence of the *Spirochæta icterohæmorrhagiæ* in wild rats, living in various environments.

Detection of the Spirochæta Icterohæmorrhagiæ by Laboratory Methods.

A. *In Man.*

The following methods have been successfully employed in detecting infection with the *Spirochæta icterohæmorrhagiæ* in human beings:

1. Examination of blood films. These have been stained for spirochætes by one of the Romanowski stains or one of the silver impregnation methods.
2. Examination of the blood by dark field illumination.
3. Injection of the blood into the peritoneal cavity of a guinea pig.

In these three methods, the earlier in the course of the disease the blood is obtained the better the chances of success. In the first two methods search must be made with the microscope for the spirochætes and as they are not very numerous in the blood of human cases, and somewhat difficult to stain these methods are not highly satisfactory. On the other hand, in early cases guinea-pig inoculation with blood is a valuable procedure and should always be done, unless the patient is first seen late in the disease. If the *Spirochæta icterohæmorrhagiæ* are present in the inoculated blood the guinea pig will usually sicken and die in about ten days. Post-mortem examination will show a well marked combination of jaundice and hemorrhage such as, so far as known, is not produced by any other infection.

In a light-skinned guinea pig a distinct yellowish tinge, especially noticeable in the ears and about the genitals, is usually observed. On dividing the skin of the abdomen in a case of this disease, the operator is at once struck with the widespread hemorrhages which lie beneath the skin and between the connective tissue planes.

They range from minute petechiæ up to massive effusions of blood perhaps a centimeter in diameter. The hemorrhages are especially well marked about the axillary and inguinal lymph-nodes and as the skin is reflected hemorrhagic areas will be seen between the fascia covering the skeletal muscles. The skin is usually quite yellow and the abdominal muscles frequently show a yellowish tinge. On opening the body cavity the liver appears distinctly enlarged and of a brownish yellow color. The spleen is not enlarged. The intestines are stained yellow and hemorrhages into the intestinal walls are of frequent occurrence. Post-peritoneal hemorrhages are frequent and abundant, especially about the kidney and adrenal. This organ is frequently the seat of marked effusions of blood. In the thorax the lungs especially attract attention, being the seat of the most characteristic gross change observed in the guinea pig. These consist of numerous sharply defined hemorrhagic foci. The description, by the Japanese, of the lungs as resembling the mottled wings of a butterfly is a very apt one. Histologically the liver and kidneys show the most characteristic changes. The liver shows an exudation of polymorphonuclear leucocytes about the bile ducts, and widespread degenerative changes of the parenchyma. Many of the cells contain an abnormal amount of pigment, while others show pronounced vacuolization and dispersion. The kidneys show an acute exudative nephritis with hemorrhages throughout the cortex.

The tissues of the guinea pig contain many spirochætes, which may be best demonstrated by staining portions of the liver by the older method of Levaditi, making sections and examining by the microscope. Dark field examination of the liver pulp will also usually reveal them.

4. Microscopic examination of the urine for spirochætes.

The urine is centrifugalized and the sediment examined by the dark field method, or films are made and stained by India ink, Romanowsky stain or a silver impregnation method. It will be recalled that the urine contains spirochætes in a variety of conditions, and one must be entirely familiar with the morphology of the *Spirochæta icterohæmorrhagiæ* to hazard a diagnosis by a microscopic examination of the urine.

The microscopic examination of the urine has a special field in expert hands to determine whether a convalescent is excreting the spirochætes in his urine and is therefore a carrier.

5. Injection of urinary sediment into the peritoneal cavity of a guinea pig.

This method has frequently been followed by positive results and should be regularly practiced. As in the injection of blood it has the decided advantage that positive results are well marked, causing the definite pathological changes in the guinea pig, above referred to.

6. Examination of tissues obtained at necropsy by the older method of Levaditi.

By this method the spirochætes may frequently be demonstrated in the viscera, especially in the kidneys.

In general, it may be stated that for the diagnosis of the disease in the living patient by laboratory procedures, guinea pig inoculation appears to be most reliable, and the method of choice; next in practical importance is the microscopical examination of blood and urine for spirochætes; and finally, attempts to cultivate the organism directly from the human subject, which appears to be a matter of considerable difficulty.

B. *In Rodents.*

Here, as in the detection of the disease in man, guinea-pig inoculation is the method of choice and reliability. The rats should preferably be taken alive, killed, and the kidneys removed at once, with precautions not to contaminate them. The kidneys should then be emulsified and the emulsion injected into the peritoneal cavity of a guinea pig, if possible using a guinea pig for each rat. The guinea pigs should then be observed for at least two weeks. If the *Spirochæta icterohæmorrhagiæ* are present the pig will become ill, show some rather variable pyrexia, become slightly jaundiced, collapse, and die in about 10 days, and at post-mortem examination will show the marked picture of jaundice and hemorrhage referred to above. Spirochætes may be demonstrated in the tissues, as previously indicated.

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